CONDITIONING FACTORS IN EXTERNAL SANDHI: AN EPG STUDY OF ENGLISH /l/ VOCALISATION

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ABSTRACT

English l-sandhi involves an allophonic alternation in alveolar contact for word-final /l/ in connected speech [4]. EPG data for five Scottish Standard English and five Southern Standard British English speakers shows that there is individual and dialectal variation in contact patterns. We analysed vocalisation rate (% of tokens with no alveolar contact) and the area of any residual alveolar contact. Word-final /l/ contact is, to some extent, onset-like before vowel-initial words and coda-like before words with a labial onset C. If the vowel has a glottal attack, however, or the onset C is /h/, sandhi is less predictable, suggesting that resyllabification is insufficient as a mechanism for conditioning tongue tip behaviour of word final /l/.

Keywords: l-sandhi, resyllabification, vocalisation, glottalisation, EPG, dialect variation

1. INTRODUCTION

Several articulatory studies have firmly established the idea that /l/ has a primary, consonantal alveolar constriction and a secondary, vocalic dorsal constriction. English /l/ has a systematic allophony conditioned by prosodic context, resulting from differences in the relative strength and timing of the consonant's constituent lingual gestures. In general, in a consonant with multiple gestures, the more constricted consonantal gesture is believed to be boosted in articulatory strength in onset position, and weakened in coda position (and is intermediate in ambisyllabic position). In terms of interarticulator timing, the intrinsically less constricted or more vocalic gesture occurs earlier relative to the consonantal gesture when the segment appears in the coda. This behaviour has been observed for English /l/ as well as for other consonants such as nasals, and has been interpreted as exemplifying a general process of gestural weakening and differential timing in the coda relative to the onset [e.g., 1, 2, 3, 5].

In syllable onset position this means English /l/ will display contact between the tongue tip or blade and the alveolar ridge. In coda position the alveolar constriction is weakened (it is shorter and has weaker contact) and may result in loss of all contact, which we will call "vocalisation" [4]. The alveolar constriction is also delayed relative to the velar constriction with the latter overlapping substantially with the preceding vowel [2]. Degree of alveolar contact can thus be used as a diagnostic for the syllable affiliation of /l/.

In citation forms, a word-final consonant is a coda, but in connected speech, a word-final consonant may be associated with both the original syllable and the following word's first syllable: a state of ambisyllabicity, said to be due to resyllabification. Scobbie & Wrench [4] found that word-final /l/ can show wide inter-speaker variation in vocalisation rate, and in the movement amplitude of the tongue tip/blade gesture (based on EMA and EPG corpus data, [6]). They also mention in passing, and on the basis of only a handful of tokens, that "final /l/ was particularly resistant to vocalisation before word-initial /h/" compared to labial consonants. This is unexpected: both /h/ and labial consonants lack a phonological specification for lingual place of articulation. Word-initial /h/ should thus block resyllabification of /l/ to onset, because */lh/ is not a possible onset of English, just as */lb/ etc. are not. In all cases, a resyllabification-based account of /l/ sandhi predicts that word-final preconsonantal /l/ should behave alike, whether the speaker is a vocaliser or not, and that resyllabification to onset should only be possible before a vowel. Our current study investigates whether there are systematic differences in the vocalisation of coda /l/ as a function of the following non-lingual consonant.

A further aspect linked to vocalisation is glottalisation. Resyllabification to onset before a vowel is not obligatory despite tendencies to maximize onsets. When resyllabification does not occur, phonetic glottalisation may be observed around the juncture. Analytically, the originally empty onset of the following vowel-initial word may be filled by a glottal stop with the glottal acting as a consonant phoneme of English and blocking resyllabification, because */lʔ/ is not a possible onset. Alternatively, the onset could be obligatorily empty, with glottalisation being a phonetic interpretation of the unfilled structure.

We will examine the behaviour of word-final /l/ before /b/, /h/ and a vowel, in a range of speakers. We will also investigate how glottalisation in the vowel context and /l/ vocalisation interact.

2. METHOD

2.1. Data recording

The hardware set-up involved simultaneous capture of EPG (at 200Hz) and acoustic data (at 44kHz) in a sound-treated studio. The software used for data collection and analysis was Articulate Assistant Advanced (v2.04 and v2.05).

2.2. Subjects and Procedure

The ten subjects are all local research staff in the possession of an individually-fitted 62-element EPG palate. All are native speakers of English, and their phonological systems fall into two broad dialect groups, Standard Southern British English (SSBE, "E" subjects) and Scottish Standard English (SSE, "S" subjects). All have typical phonological systems for their dialect.

Subjects wore their EPG palates for at least half an hour before the recording time. The stimulus sentences, with which the subject had previously been familiarized, were presented on a screen one at a time. Sentences were presented in four pseudo-randomised blocks, the same for each subject. Technical faults halted data collection from S1 after 3 blocks and 3 items (*n*=73), and rendered 7 tokens from S2 unusable (*n*=89). EPG data from S5 are unusable for analysis of degree of contact due to a different palate design, but are suitable for distinguishing consonantal from vocalized tokens.

2.3. Materials

24 prompt sentences were randomly interspersed with 34 unrelated sentences in 4 blocks. The prompt sentences had /l/ or /lC/ in a /C_{labial}i__iC_{labial}/ context. /l/ was a word-initial onset, word-final and preconsonantal (i.e. followed by /h/ or /b), or word-final and prevocalic (followed by /i/). A fake geminate was included too. The five target structures /i#li/, /il#i/, /il#bi/, /il#hi/, /il#li/ (cf. Table 1) appeared in meaningful prompt sentences, one per block (e.g. *We can* <u>*peel heaps of*</u> *asparagus stalks* and *We can* <u>*peel heaps of*</u> *vegetable leaves*). The /bi#li/ context is not analysed here: *be* was often unstressed, and /b/ is unaspirated. In the following, /l/ thus always occurs after an unreduced syllable and before a lexically stressed syllable in an accented word.

Table 1: Materials. Each of the 12 parts was used in two different sentence variants per block, giving between 2 and 6 tokens of each structure per block.

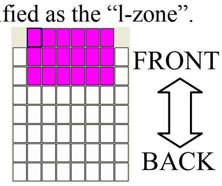
Target structure		*n*	part of prompt sentences
Onset	pi # li	16	pee Lima's and Rio's…
			pee leeward in …
	bi # li	8	be leaving on time for …
Gem	pil # li	8	peel lemurs for/in …
Coda_b	pil # bi	16	peel beavers in/on …
			peel BBC …
Coda_h	pil # hi	24	peel heaving and retching …
			peel heaps of …
			peel haematite stickers …
Ambi-syllabic	pil # i	24	peel Eve an/any …
			peel Eva some …
			peel evening oil/wear …

2.4. Analysis

All data was annotated on the basis of the acoustics to enable extraction of EPG frames. An "l-interval" was labelled, including the oral release of the previous labial stop in the carrier phrase (/p/ from *pee* or *peel*), aspiration, the /i/ of that word, the /l/, any other adjacent consonants, and all of the /i/ of the second word (e.g., to the onset of /p/ in *heaps*).

Alveolar contact during the /l/-interval was defined by reference to an "l-zone" of 18 contacts in the three front rows of the palate (cf. Fig. 1). If any contact at all occurred in this area during the l-interval, the token was coded as "consonantal", except for 6 cases with contact at the very end or start of the l-interval due to adjacent segments.

Figure 1. EPG normalised palate showing the 18 contacts identified as the "l-zone".



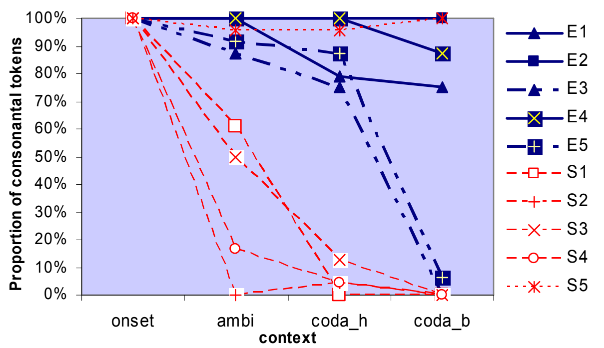
For each consonantal token, the frame of maximum number of contacts in the l-zone was identified. From this frame, the measure "cons-l" was defined as percent l-zone electrodes contacted.

3. RESULTS

3.1. Binary analysis of contact

First, we present results for the presence or absence of any contact at all in the l-zone during the l-interval. All speakers have 100% consonantal /l/ in word-initial position (Fig 2) and fake geminate context (not shown). Other contexts are more variable (Fig 2). Vocalisation rates in /il#i/ (the ambisyllabic context) will be explored in more detail below with reference to glottalisation.

Figure 2. Percent of /l/ tokens with any cons-l contact in one word-initial and three word-final contexts.



While speakers vary widely in their behaviour, variation seems to fall into three groups, depending on the vocalisation rates in different phonological contexts. Vocalisers S1, S2, S3 & S4 ("V" group) vocalise coda /l/. Contacters ("C" group) E1, E2, E4 & S5 tend to have an alveolar consonantal /l/. Glottal transparency "GT" speakers E3 & E5 vocalise /l/ before /b/ but not before /h/. No speakers show the reverse pattern of vocalisation before /h/ but not before /b/.

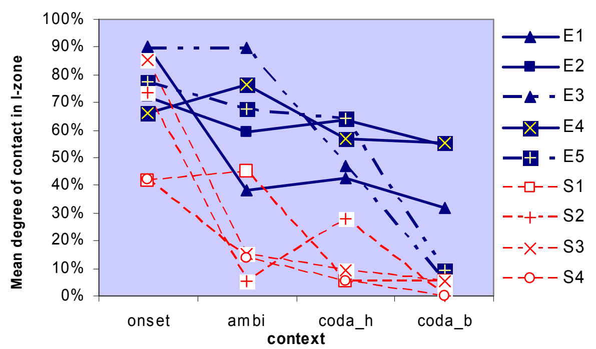
The V group has a wide range of vocalisation rate before /i/, so the ambisyllabic context appears to be more gradiently variable than the pre-consonantal contexts. Overall, the Scottish speakers (bar S5) have a markedly lower rate of consonantal /l/, so we suspect /l/-vocalisation may be a general dialectal feature.

3.2. Gradient analysis of degree of contact

Looking at the consonantal tokens only, for each token we obtained the maximally-contacted cons-l frame and calculated the mean percent of contact for each of the five target structures. In the absence of statistical analysis, we conclude tentatively that the same systematic contextual and interspeaker variation seen in the binary contact analysis (Section 3.) is visible in Fig. 3. Additionally, there are clear individual differences in the phonetic extent of cons-l contact.

These results show that the pattern of presence vs. absence of contact is comparable to the pattern of greater vs. lesser contact. They also suggest that in subjects with consistently high levels of consonantal /l/ in the coda, the coda contexts are nevertheless weaker than the onset context. In the ambisyllabic context there is a lot of variation from onset-like contact levels right through to almost complete vocalisation (S2, S3 & S4). SSE speakers generally have low cons-l values, paralleling their high vocalisation rate in Fig. 2. Two (S2 & S3) also have a relatively low mean cons-l onset value.

Figure 3. Mean maximum cons-l contact for consonantal tokens only in the four contexts.



3.3. Glottalisation, ambisyllabicity

In the ambisyllabic context all speakers used word-initial glottal reinforcement at least some of the time. Perhaps vocalisation rates in the ambisyllabic context are a function of glottalisation. We coded glottalisation when [ʔ] or creak was identified auditorily and visually from the spectrogram and waveform and agreed by two of the authors.

In all, 68% of /il#i/ tokens (n=188) were glottalised. Table 2 gives the % vocalised (Voc) and consonantal (Cons) productions of target ambisyllabic /l/ according to the presence (ʔ) or absence (.) of glottalisation. Again, a difference between the dialects emerges, with Scottish speakers using overall more glottalisation in (but not restricted to) the vocalised /l/ utterances.

Among Contacters: E1 & E4 have exclusively glottalisation, and exclusively consonantal /l/; E2 & S5 have exclusively consonantal /l/ (bar one token) of which about ¾ feature glottalisation. The GT group (E3 & E5) who vocalise before /b/ but not before /h/ have mostly consonantal tokens, and juncture glottalisation, if present (92% of E5 and

38% of E3), patterns with the phoneme /h/. Otherwise, consonantal [l] is truly intervocalic (50% of E3). About 8% of E5's vocalised tokens show concomitant glottalisation, comparable to the small number of tokens which that subject vocalises before /h/. Strangely, 12% of E3's tokens are vocalised despite the absence of glottalisation (i.e. despite being truly intervocalic).

Table 2: Proportions of vocalic (Voc) and consonantal (Cons) ambisyllabic tokens that are glottalised or not. Empty cells denote zero occurrences.

% tokens	E1-C		E2-C		E3-GT		E4-C		E5-GT	
	ʔ	.	ʔ	.	ʔ	.	ʔ	.	ʔ	.
Voc						12			8	
Cons	100		75	25	38	50	100		92	

% tokens	S1-V		S2-V		S3-V		S4-V		S5-C	
	ʔ	.	ʔ	.	ʔ	.	ʔ	.	ʔ	.
Voc	22	17	100		42	4	83			4
Cons		61			46	8	17		71	25

Most interesting is the V group (S1-S4), because they vary so much in the ambisyllabic context, from 0% to 61% consonantal tokens. S2 vocalises 100% before [ʔ], just like their pre-/h/ context. S4 appears similar, with 100% glottalisation in the ambisyllabic context. However, though 83% are vocalised, surprisingly 17% have alveolar contact. Like S2, S1 completely avoids consonantal /l/ with glottalisation, but actually differs a great deal: S1 has a consonantal /l/ in 61% of tokens (a truly intervocalic one) rather than vocalisation. When S1 does vocalise, glottalisation is present only about half the time. Finally, S3 has a preference for glottalisation (88% of tokens), but there is a roughly equal number of vocalised and consonantal tokens of /l/.

4. DISCUSSION AND CONCLUSION

Speakers vary greatly in *how* the difference between onset and coda /l/ is manifested. Some speakers show subtle differences in the degree of alveolar contact, while more radical allophony conditions absence of alveolar contact in coda /l/. Relative differences in the degree of contact between the target contexts seems to pattern well with a speaker's tendency to lose alveolar contact completely. Dialectally, Scottish speakers show more vocalised productions (but not S5).

As expected, vocalised word-final /l/ tends somewhat to occur before a following consonant-initial word. If the following word begins with a phonemic vowel (the ambisyllabic target), the vowel may be accompanied by phonetic glottalisation, often [ʔ]. This does not cause, however, any clear effect on the consonantal nature of the /l/. The C-group, consonantal in codas, are also consonantal in the ambisyllabic context, and this context is typically glottalised. The V-group (all Scottish) also prefer glottalised productions, but this time in the context of vocalised /l/, though from S3 we see that glottalisation is not an automatic bar on consonantal /l/. Moreover, both GT speakers extend transparency from phoneme /h/ to [ʔ]: neither conditions vocalisation like /b/.

Mostly, a speaker's /l/ allophone is the same before /b/ and /h/: vocalised before both, or neither. But two GT speakers vocalise before /b/ but not /h/. Thus, as Scobbie & Wrench [4] predict, /h/ and labial consonants may differ in how they condition the behaviour of word-final /l/.

If syllable structure were the *only* factor responsible, then, given the illegality of */lh/ & */lb/ as onsets, /h/ and /b/ would always pattern alike. Thus resyllabification is not, as it may seem, the obvious mechanism for /l/-sandhi. The varying effects of word-initial [ʔ] are equally challenging. While /h/ and [ʔ] are more likely to behave in a transparent way than /b/, the linguistic level of this transparency remains unclear. We can be sure, however, that in connected speech, word-to-word interactions are conditioned by relationships are like*, but not identical to*, lexical syllabification.

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5. REFERENCES

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